

Africa Partnership Station

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LONG-TERM GOALS

The long-range goals of this research are to assist in the development of the ONR-sponsored Africa Partnership Station to be located in Accra, Ghana, Africa.

OBJECTIVES

1. Participate in planning the initial stages of the partnership program, attend a week-long field event based out of Accra, Ghana, Africa, and assist in guiding activities through the first year of the program.

APPROACH

The ONR-sponsored project, which is being facilitated by CNE-C6F's Africa Partnership Station (APS) is presently in the early stages of development. The overall goals of the program are to assist emerging West African nations in obtaining knowledge of and skills working in shallow coastal environments, developing a remote sensing capability, and creating a partnership where education and capacity building exercises are implemented in the host countries. The program is envisioned to have a shallow water component where various researchers from the U.S. and around the world will provide in-depth training and expertise in nearshore processes including theoretical knowledge, numerical model development and execution, satellite imagery analysis, and field observation techniques, processing, and assimilation of data with models. In order to facilitate the development of the program a coastal processes workshop (of which this report is based) was held Accra, Ghana, in April 2008 where team members were introduced to the region, met with colleagues from the host countries, toured UG facilities where activities will take place, and made presentations related to nearshore processes research.

The coastal and marine environment of Ghana contributes significantly to the economic development and security of the country. Ghana has demarcated a 200 nautical mile Exclusive Economic Zone (EEZ) within the framework of the United Nations Convention on the Law of the Sea (UNCLOS). This has brought vast living and non-living resources under Ghanaian jurisdiction. Furthermore, shipping traffic continues to rise and associated problems with ballast water and potential oil spill raises concern for ecosystem health. The ability for monitoring the resource and the environment will contribute immensely to the management of the marine ecosystem.

The coastline of Ghana measures about 550 km and is generally a low-lying area not exceeding 200 m above sea level. It is bordered by a narrow continental shelf extending outwards between 30 and 90 km. Presently, there is an increasing rate of erosion along the coastline. Shoreline recession is caused

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by the interplay of several factors including prevailing wave regimes, damming of rivers, and removal of vegetative cover. In at least three sites visited during the workshop, the erosion is so rapid that major coastal roadways are being washed into the sea or threatened (Figure 1). Limitations in infrastructure to repair the roadway or use alternative routes (of which there are none presently constructed) make this a serious problem for local communities and commerce. Understanding the changes to the sediment transport that have occurred at these two sites is critical to forecasting changes along other parts of the coastline, most of which has shown a marked loss of overall sediment within the past 2 decades (Figure 2) based on widely acknowledged anecdotal observations from UG researchers and the local populace.



Figure 1. Active erosion at Ada (left bottom), Anyanwi (right bottom), and Accra (top panels) showing the effects of rapid beach erosion threatening major coastal roadways in the region.



Figure 2. Rocky coastline along the region just to the west of Ghana (left). This region was characterized by a wide sandy beach just a decade before, similar to adjacent beaches nearby (right).

WORK COMPLETED

The agenda for the initial April Workshop was developed and implemented in collaboration with US, European, and African partners. The following describes the basis for the activities at the workshop, which involved four days of seminars, instruction, and discussion and two days of field activities including tours of the coastline and jetting operations. The nature of the daily activities was based on the above discussion with particular emphasis on developing an appropriate capability (*e.g.*, wave prediction, surf forecast, or bathymetric evolution model). The bulk of the effort was devoted to implementing the agenda and preparing presentations, demonstrations and field activities at the workshop.

Central to the workshop was the introduction to expertise and experience in nearshore processes research provided by the invited U.S. and European professors. Starting from basic concepts they attempted to convey in an orderly manner how our vision of nearshore processes research should be addressed in developing regions where the expertise and experience does not presently exist, but the interest and relevance is high. The focus was based on the overarching goal that in any observational research program with reaches to the nearshore, it is imperative to measure properties and conditions at the bottom, surface, and lateral boundaries over the appropriate scale of interest (which could range a few hundred meters to many kilometers). This leads to critical observational needs for regional scale studies involving numerical modeling and prediction.

The most basic property to measure is the bathymetry. That is, it is important to know the basic properties of the bottom boundary condition, namely its location and how it changes in space and time. This requires that measurement capabilities be developed to accurately survey the bottom topography from the inner shelf, through the surf zone, and onto the beach face. The instruments of choice would be differential-GPS based survey vehicles on land (buggies, dollies, walking) and at sea (personal watercraft and other boats equipped with acoustic altimeters, temperature sensor, and onboard navigation). Developing modern survey capability is, in our view, the highest priority. Without this capability it is difficult to do any nearshore processes research.

The second basic property to measure is the mean water level and how it is modulated on various tidal cycles. This is essentially the most basic surface boundary condition that determines the mean water

depth, shoreline position (at the interface with the beach), and the tidal fluctuations that are of order one importance to beaches with non-negligible tidal amplitudes. In general, it is of interest to know the slowly varying (over several to many minutes) water level outside the surf zone to decouple the influences of larger scale processes (*e.g.*, tides, atmospheric pressure and wind fields, shelf processes) from smaller scale processes associated with the surf zone (*e.g.*, set-up). Most commonly these measurements are made with standard tide gauges. It is of interest to have a well-developed network of tide gauges from which to observe the mean water levels outside the influence of the surf, and to be able to predict the tidal amplitudes for any given location in the region. This capability is probably the most well-established in that tidal gauges exist in Ghana at Takoradi and in neighboring Lome, Togo.

Lateral boundary conditions occur at four locations of a hypothetical rectangular domain aligned with the coastline: the seaward boundary, the shoreward boundary (shoreline), and two lateral (side) boundary conditions. The most basic seaward boundary condition is associated with the input of momentum and energy primarily through surface gravity waves (the incident sea and swell waves driven by wind in the open ocean). Of particular interest is the distribution of incident wave energy as a function of frequency and direction; that is, how energetic are the waves and where are they coming from. The best way to measure the directional wave field in intermediate water (of order 20-200 m depths) is through moored directional wave buoys with (optimally) radio link to shore. Directional wave data can also be obtained from bottom mounted PUV gauges (which measure dynamic pressure and bi-directional horizontal velocity fluctuations near the sea bed), or arrays of bottom mounted pressure sensors in various geometries (with generally higher directional resolution as the number and dimensions of the array increases).

The shoreline boundary condition is, at first order, defined by the intersection of the mean (time-averaged) water level and the sloping beach face and a reflection coefficient defining the fraction of incident wave energy reflected off the beach face and radiated back out to sea. This information, in conjunction with the offshore directional wave measurements) tells us how much incident wave energy has been dissipation in the surf zone, how big the waves are at the shoreline (from the reflection coefficient), and how large the wave-induced water level change are (the shoreline set-up and/or surge level given by the difference between the still-water-level shoreline and the observed shoreline position). The mean shoreline is difficult to measure because it is constantly moving and foreshore dynamics have a big impact on the behavior right at the swash edge; thus, this measurement is not routinely made. Most practical would be observations from video-based observations of run-up (swash oscillations) or extracted from time-average video imagery. Although restricted to daylight hours and relatively clear weather conditions, the remote nature of the techniques are attractive in that they are relatively easy to deploy and maintain, and their spatial coverage (of order 1-5 km) can capture a relatively large region of the coastline.

The side boundary conditions would be of interest, but in general are impractical to measure on open coast beaches as they would require extremely large arrays of instruments to properly sample the flow fields and bi-directional energy fluxes across the boundaries. Domains bordered by structures or natural barriers are more easily accounted; however, in most situations a periodic or absorbing boundary condition must be employed in order to properly model the dynamics within the domain. From this discussion, specific instrument needs were discussed. The highest priorities were GPS based survey systems, shoreline monitoring systems, and directional wave buoys. With observations obtained with these instrument systems, models could be initialized and run to make predictions, and large scale coastal behavior could be addressed in terms of the observed evolution in bathymetry coincident with changing antecedent wave conditions. And finally, nested intensive experiments could

be designed to utilize the observing capabilities to augment and support the field efforts, and to put the results in context of the larger scale coastal evolution. Keeping a long-term goal of creating observational capabilities similar to those described above is the over-riding factor in guiding (at least a portion of) the workshop agenda for the initial April Workshop (Appendix A).

RESULTS

Research goals for UG research efforts within the framework of the APS were discussed, and evolved to a break-down of processes based on scale. Four general needs were outlined and include (1) large scale coastline development of order 100-1000 km, (2), large scale shelf processes of order 100-1000 km, (3) large scale nearshore processes of order 10-100 km, and (4) medium scale coastal inlets and adjacent beaches of order 1-10 km. Each will be discussed briefly in turn below. In many cases, the needs of the different objectives overlap, both in observational needs but also nested modeling capabilities. Dissemination of findings from the program would be through regional workshops hosted by UG, development of a web-based coastal observatory, journal papers, and through presentations at international conferences.

The program structure was discussed. It was envisioned that Dr. Wiafe and Mr. Ababio would be the principal investigators for the UG APS efforts. Research students were identified for the different projects from both the Department of Oceanography and Fisheries (Mr. Kwame Adu Agyekum) and the Department of Physics (Mr. Abraham Amankwah and Mr. Laryea Wahab Sowah). A wealth of research assistants and undergraduate students within the departments will contribute significantly. It was understood that a supervisory team of international experts would be needed to fulfill the objectives through training and oversight, and that the students should undergo extensive visits to the international collaborator institutions. Workshops should be conducted as equipment is procured and modeling capabilities increase to ensure that the research progresses appropriately in a timely manner.

Of critical importance to the research is improved internet access through upgraded infrastructure to UG in general, and in particular to the Dept. of Oceanography and Fisheries. This need has already been identified and some efforts are being put forward to ensure that this happens. Increased bandwidth will facilitate exchange of research results, allow for data mining from global sources, and the timely acquisition of satellite imagery.

Equipment needs include a directional wave buoy network that would benefit each project outlined above, as well as the entire Gulf of Guinea region as part of the APS. The cost of such a program was recognized as being prohibitively expensive for the guidelines set forth in the proposal process. Identified was a clear need to partner with U.S. agencies such as NOAA and naval labs, or international academic institutions such as UNESCO and the Coastal Data Information Program run by Scripps Institution of Oceanography, to develop a regional wave observation network.

IMPACT/APPLICATIONS

The workshop and subsequent report served as an initial effort to begin development of capabilities in coastal processes research in the area.

TRANSITIONS

Capacity building exercises will continue within the program, including instructional workshops and development of observational capabilities for shelf and surf zone processes.

RELATED PROJECTS

Ongoing partnership with other U. S. Naval and oceanographic entities in the US (UNH, WHOI, RSMAS, NPS), Ghana (Univ. Ghana), Europe (UNESCO), and in neighboring regions.

REFERENCES

PUBLICATIONS

Ababio, S., T. C. Lippmann, D. Roelvink, A. Vogel, and G. Wiafe, 2008, Coastal Processes Workshop Report for the Africa Partnership Station, *Coastal Geosciences, Office of Naval Research* [submitted, non-refereed]